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(54) **TANDEM INTERMEDIATE-TRANSFER TYPE IMAGE FORMING APPARATUS**

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G03G 15/01 (2006.01)

(52) **U.S. Cl.** **399/299**; 399/302; 399/308; 399/313

(58) **Field of Classification Search** 399/299, 399/302, 308, 313
See application file for complete search history.

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(57) **ABSTRACT**

An image forming unit includes four photoconductors, a belt extended around a driving roller and an extension-cum-primary transfer roller. Three primary transfer rollers sandwich the belt in association with a corresponding photoconductor. The extension-cum-primary transfer roller serves both as an extension roller and a primary transfer roller.

13 Claims, 3 Drawing Sheets

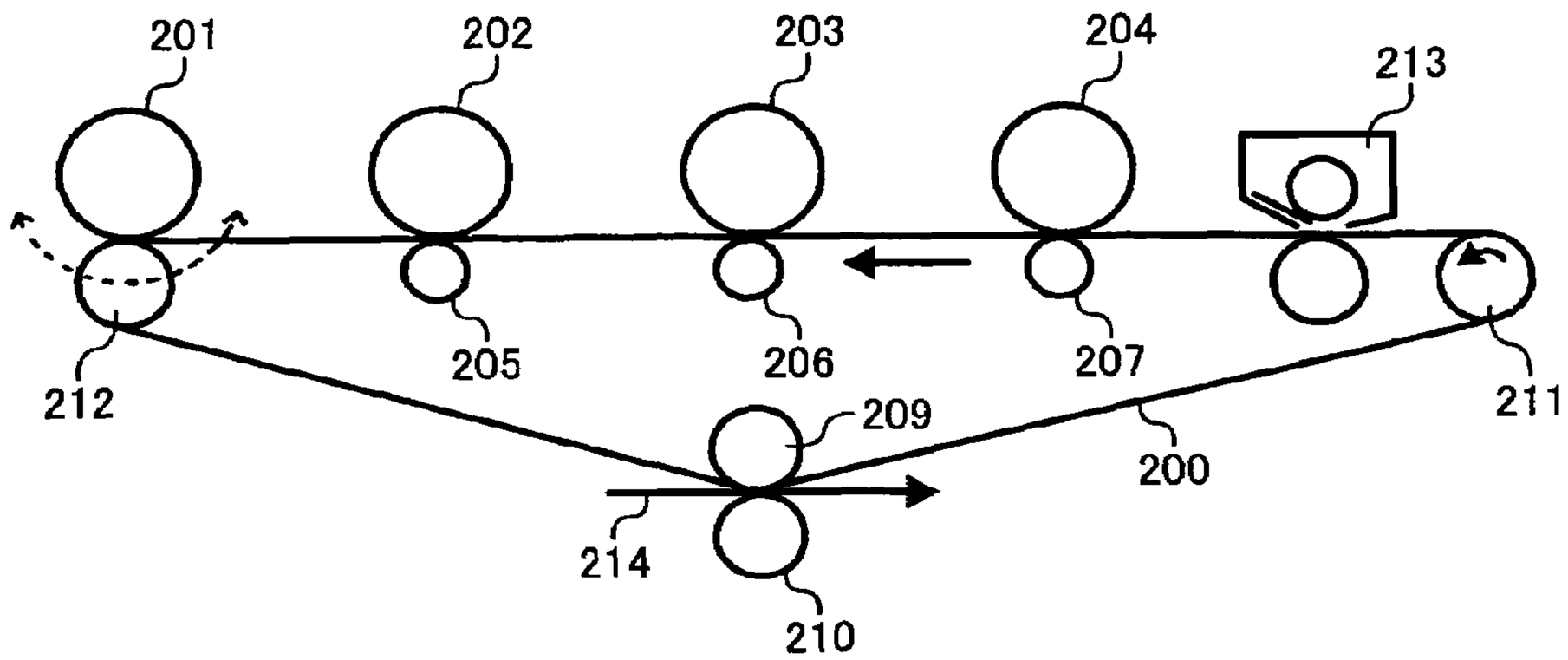


FIG. 1

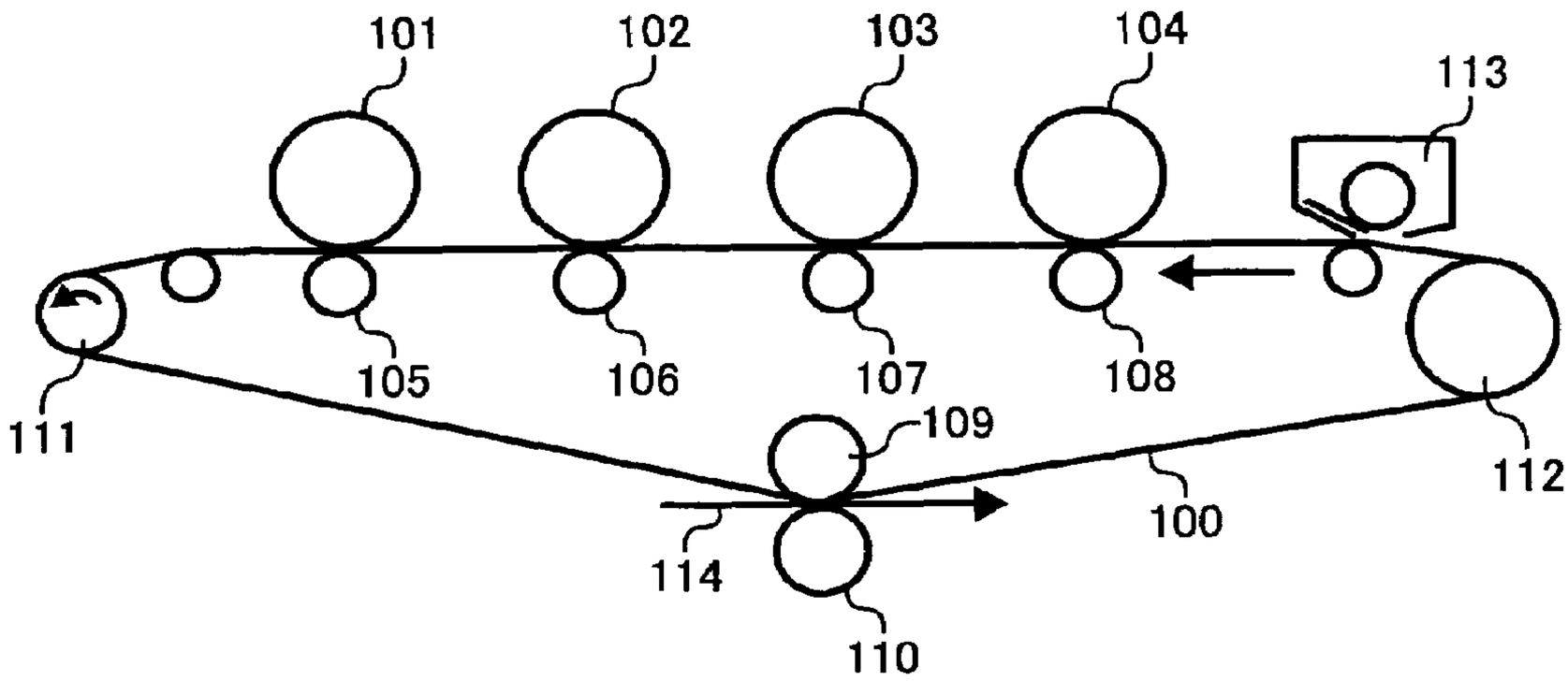

101
102
103
104
113
105
106
107
108
111
109
112
100
114
110

FIG. 2

201
202
203
204
213
205
206
207
212
209
211
200
214
210

FIG. 3

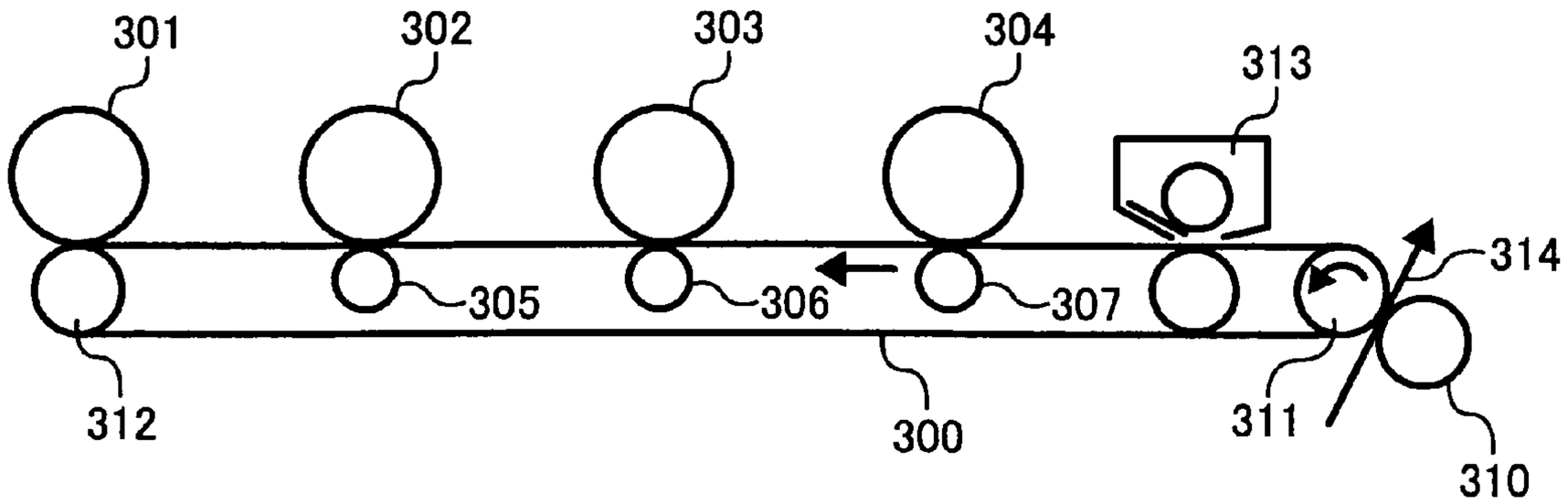


FIG. 4

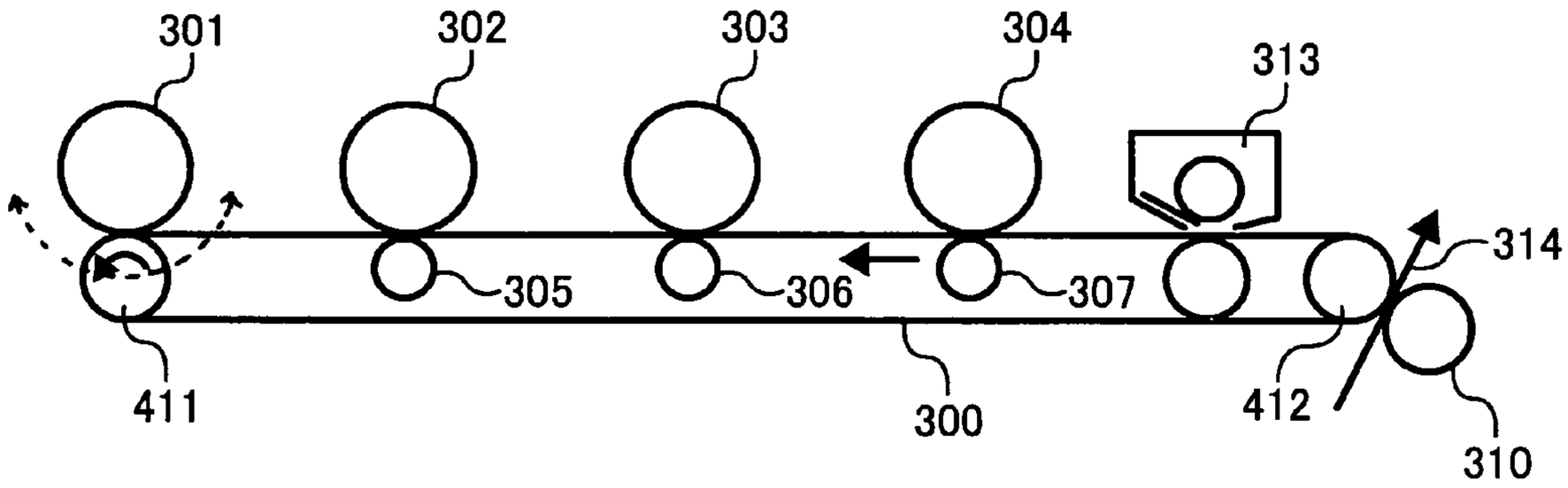


FIG. 5

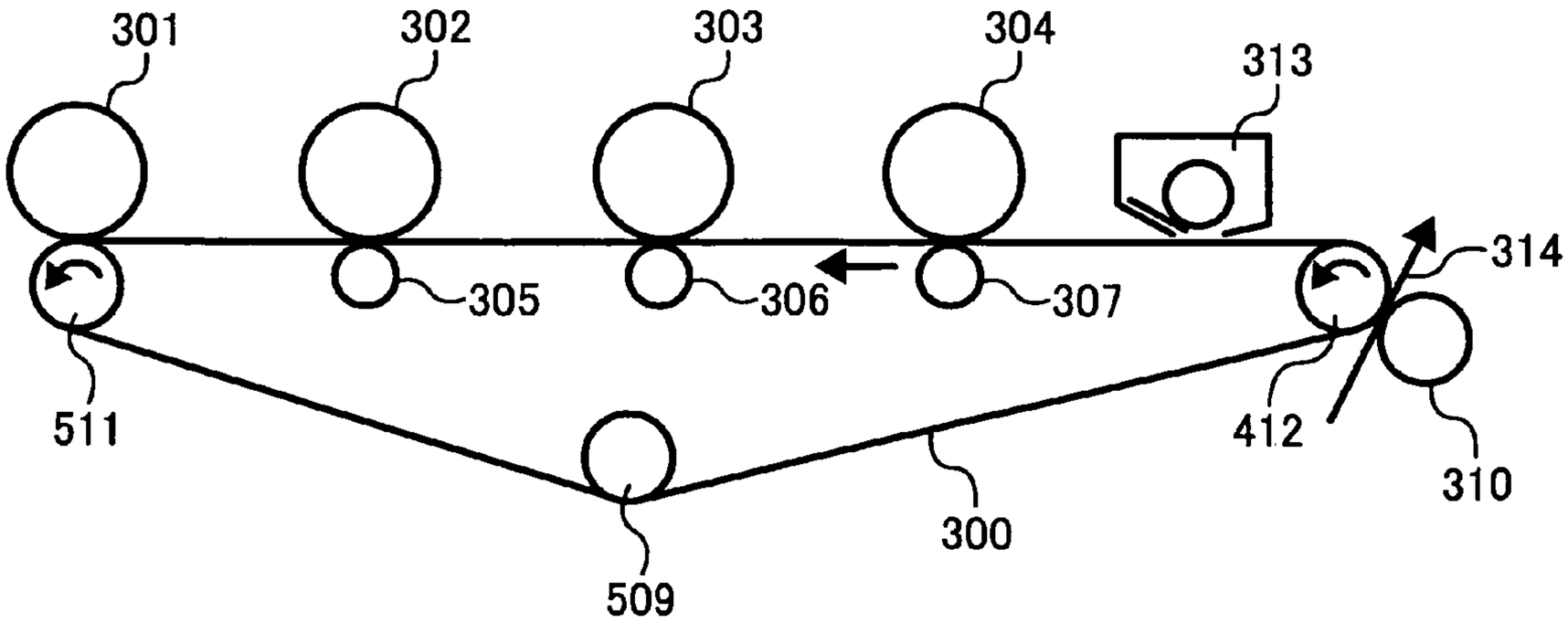


FIG. 6

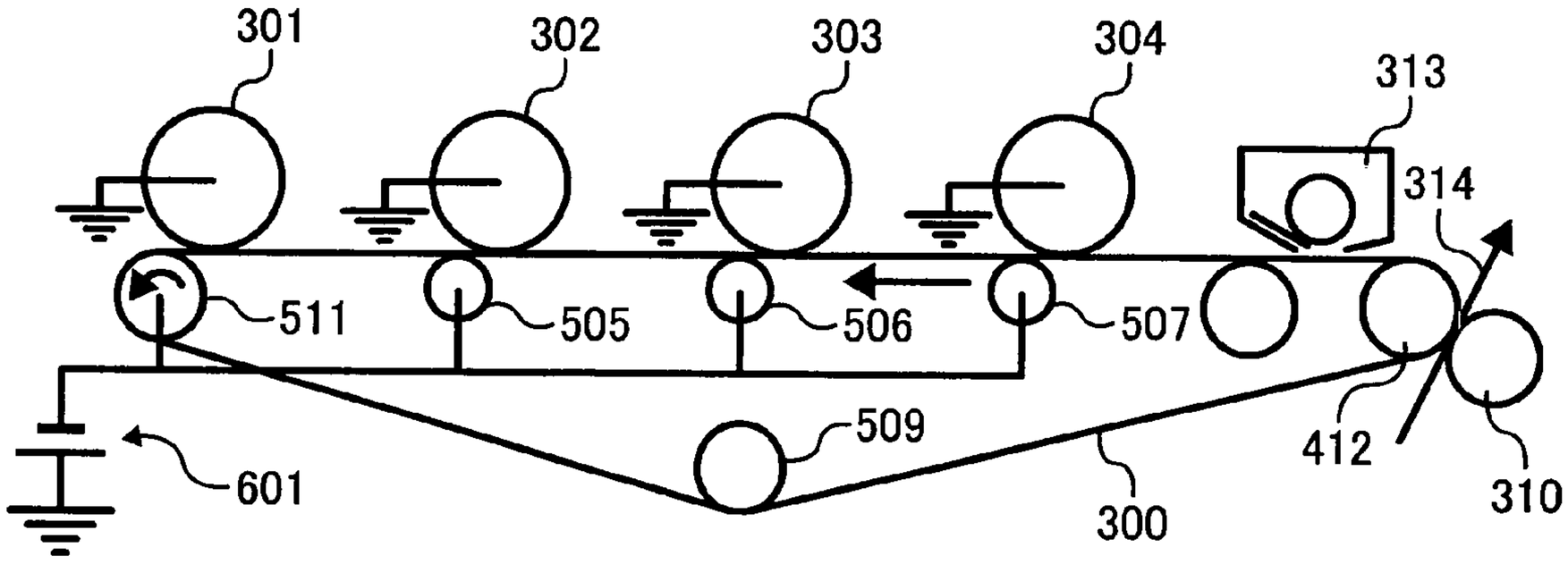
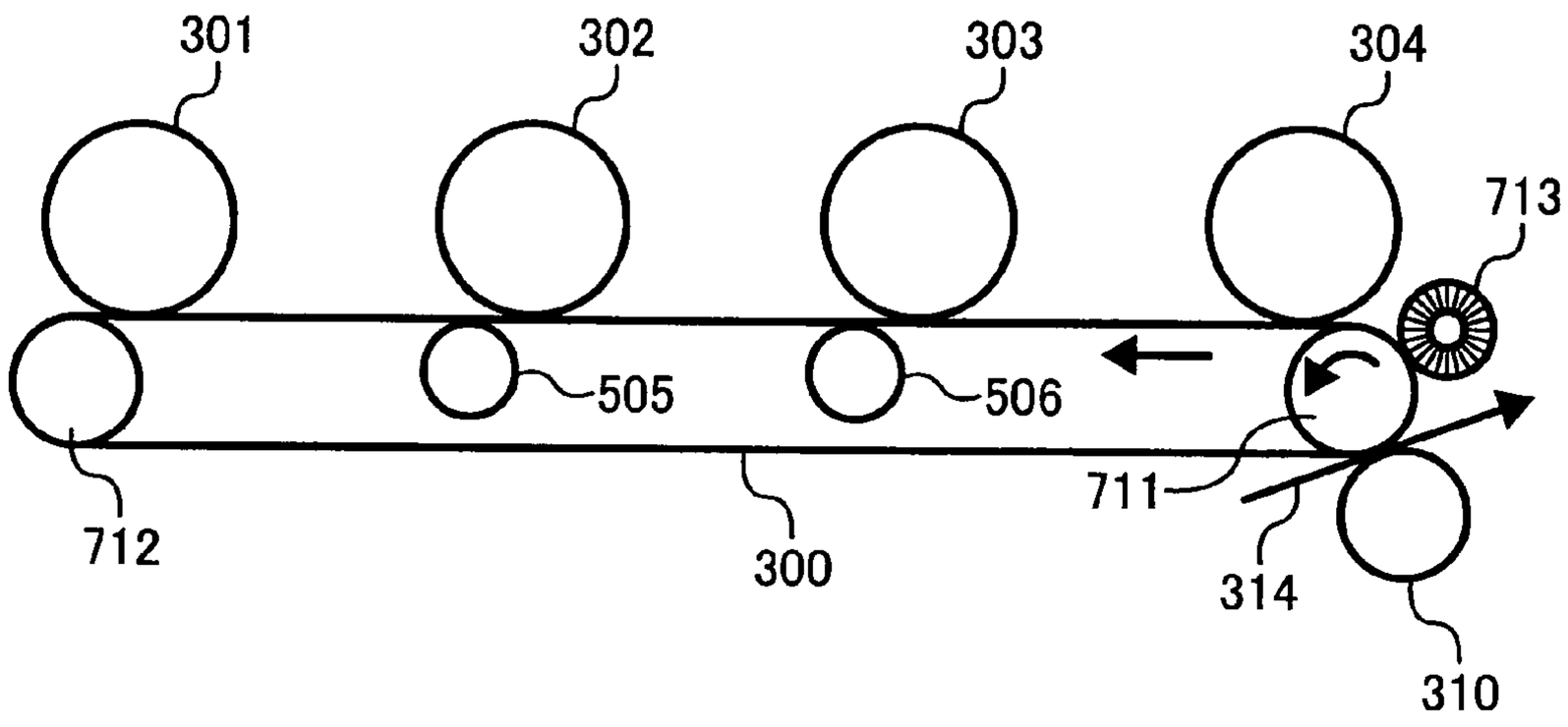

301
302
303
304
313
314
511
505
506
507
509
601
412
310
300

FIG. 7


301
302
303
304
713
505
506
712
300
711
314
310

TANDEM INTERMEDIATE-TRANSFER TYPE IMAGE FORMING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

The present document incorporates by reference the entire contents of Japanese priority document, 2005-129549 filed in Japan on Apr. 27, 2005.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to a tandem-type image forming apparatus and particularly relates to an intermediate transfer type image forming apparatus.

2. Description of the Related Art

Tandem-type color image forming apparatuses, which have a plurality of photoconductors, are more efficient because they can output more pages per unit time. However, the tandem-type color image forming apparatuses have a disadvantage that, when superimposing all the monochrome toner images formed on the photoconductors on one another to form a full-color image, it is difficult to align writing positions of the toner images. If the writing positions are not aligned correctly, the image quality degrades.

Two types of tandem-type color image forming apparatuses are known: a direct transfer type and an intermediate transfer type. In the direct transfer type, toner images are directly transferred from the photoconductors onto a final transfer material. In the intermediate transfer type, toner images are first transferred from the photoconductors onto an intermediate transfer member, and then onto the final transfer material. The final transfer material is, for example, a paper.

It is easier to correctly align the writing positions of the toner images in the intermediate transfer type than in the direct transfer type. This is because, the toner images are first transferred onto the intermediate transfer member of a certain material in the intermediate transfer type, whereas the toner images are transferred onto various transfer materials in the direct transfer type.

Because the tandem-type color image forming apparatus includes a plurality of photoconductors, the direct transfer type requires a longer transfer material conveying belt and the intermediate transfer type requires a longer intermediate transfer belt than when there is only one photoconductor. Moreover, the belts are extended around a plurality of rollers, which makes the structure complex.

Japanese Patent Application Laid Open No. H8-305184 discloses a direct transfer type image forming apparatus in which a driving roller and a subordinate roller are made to serve as transfer charging rollers whereby the number of rollers can be reduced and a shorter transfer material conveying belt can be used. However, the issue of difficulty in aligning the toner images remains unsolved.

Japanese Patent Application Laid Open No. H7-43976 discloses an image forming apparatus including four fan-shaped image forming units for black, yellow, magenta, and cyan, arranged in a circular ring, which transfer toner images onto an intermediate transfer belt at a single primary transfer position. Moreover, a subordinate roller is caused to function as a transfer charging roller. As a result, the number of rollers can be reduced, and a shorter transfer material conveying belt can be used. Moreover, because there is only one primary transfer position, costs are reduced and the apparatus can be made compact. However, there is a disadvantage that the output capacity of color images per unit time is small.

SUMMARY OF THE INVENTION

It is an object of the present invention to at least partially solve the problems in the conventional technology.

According to an aspect of the present invention, an image forming apparatus includes a belt that rotates around a plurality of rollers; a plurality of image carriers configured to carry toner images, the image carriers arranged in contact with a first side of the belt at a plurality of primary transfer positions; a plurality of primary transfer members arranged in contact with a second side of the belt opposite to the first side, wherein each primary transfer member applies a voltage to a corresponding one of the primary transfer positions so that toner images on each image carrier are sequentially transferred onto the belt to be superposed on one another and then transferred at once onto a transfer material at a secondary transfer position, wherein at least one of the rollers serves as at least one of the primary transfer members.

The above and other objects, features, advantages and technical and industrial significance of this invention will be better understood by reading the following detailed description of presently preferred embodiments of the invention, when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic of an arrangement of a conventional image forming apparatus;

FIG. **2** is a schematic of an arrangement of a first embodiment according to the present invention;

FIG. **3** is a schematic of an arrangement of a second embodiment according to the present invention;

FIG. **4** is a schematic of an arrangement of a third embodiment according to the present invention;

FIG. **5** is a schematic of an arrangement of a fifth embodiment according to the present invention;

FIG. **6** is a schematic of an arrangement of a seventh embodiment according to the present invention; and

FIG. **7** is a schematic of an arrangement of an eighth embodiment according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Exemplary embodiments of the present invention will be described below with reference to accompanying drawings. The present invention is not limited to these embodiments.

FIG. **1** is a schematic for explaining a conventional image forming apparatus. The image forming apparatus includes an image forming unit including four photoconductors **101** to **104**. An intermediate transfer belt **100** is extended around a driving roller **111** that drives the intermediate transfer belt **100**, an extension roller **112**, and a pair of secondary transfer rollers **109** and **110**. Four primary transfer rollers **105** to **108** sandwich the intermediate transfer belt **100** in association with a corresponding one of the photoconductors **101** to **104**. Predetermined voltages are applied onto the primary transfer rollers **105** to **108** so that monochrome toner images formed on each of the photoconductors **104** to **101** are superposed in that order onto the intermediate transfer belt **100** to form a full-color image. Subsequently, the color image on the intermediate transfer belt **100** is transferred onto a sheet **114** of paper, which is a transfer material, by applying a predeter-

mined voltage onto the secondary transfer roller **110**. The color image is fixed onto the sheet **114** by a fixing unit (not shown), and the sheet **114** is output. Excess toner remaining on the intermediate transfer belt **100**, which was not transferred onto the sheet **114** of paper by secondary transfer roller **110**, is collected by a toner cleaning unit **113**. The toner cleaning unit **113** is, for example, a blade.

FIG. **2** is a schematic of an arrangement according to a first embodiment of the present invention. An image forming unit according to the first embodiment includes four photoconductors **201** to **204**. An intermediate transfer belt **200** is extended around a driving roller **211** that drives the intermediate transfer belt **200**, an extension-cum-primary transfer roller **212**, and a pair of secondary transfer rollers (secondary transfer members) **209** and **210**. Three primary transfer rollers **205** to **207** sandwich the intermediate transfer belt **200** in association with a corresponding photoconductor among the photoconductors **202** to **204**. Predetermined voltages are applied to the primary transfer rollers **205** to **207** so that three monochrome toner images on the photoconductors **204**, **203**, and **202** are superposed, in that order, onto the intermediate transfer belt **200** to form a three-color image. According to the first embodiment, the extension-cum-primary transfer roller **212** serves both as an extension roller and a primary transfer roller. In other words, in addition to functioning as an extension roller, the extension-cum-primary transfer roller **212** corresponds to a primary transfer roller for the photoconductor **201**.

A predetermined voltage is applied to the extension-cum-primary transfer roller **212**, so that the toner image on the photoconductor **201** is transferred to the intermediate transfer belt **200** an superimposed onto the three-color image, thereby forming a full-color image. Subsequently, in the same manner as the conventional example, the color image formed on the intermediate transfer belt **200** is transferred onto a sheet **214** of paper, which is a transfer material, by applying a predetermined voltage onto the secondary transfer roller **210**. The color image is fixed by a fixing unit (not shown) onto the sheet **214**, and the sheet **214** is output. Excess toner remaining on the intermediate transfer belt **200**, which was not transferred onto the sheet **214** by the secondary transfer roller **210**, is collected by a toner cleaning unit **213**. The toner cleaning unit **213** is, for example, a blade.

Because the intermediate transfer belt **200** is always under tension, its length can change over time. Changes in the length of the intermediate transfer belt **200** can be compensated by rotating the driving roller **211** along a circumference of a driving gear or rotating the extension-cum-primary transfer roller **212** along a circumference of the photoconductor **201**.

An arrangement is shown in FIG. **2** in which one roller, i.e., the extension-cum-primary transfer roller **212**, functions as a primary transfer roller; however, two or more of the rollers **212**, **205**, **206**, and **207** can be made to function as primary transfer rollers.

According to the first embodiment, at least one roller functions as both the primary transfer roller and the extension roller so that at least one roller can be omitted, thereby reducing cost. Moreover, a shorter intermediate transfer belt can be used, thereby reducing cost and size of an image forming apparatus.

FIG. **3** is a schematic of an arrangement according to a second embodiment of the present invention. The secondary transfer roller **209** in the first embodiment shown in FIG. **2** is omitted in the second embodiment. Instead, a driving roller is made to serve as a secondary transfer roller.

An image forming unit according to the second embodiment includes four photoconductors **301** to **304**. An intermediate transfer belt **300** is extended around an extension-cum-driving roller **311** that drives the intermediate transfer belt **300**, and an extension-cum-primary transfer roller **312**. Three primary transfer rollers **305** to **307** sandwich the intermediate transfer belt **300** in association with a corresponding one of the photoconductors **302** to **304**. The extension-cum-primary transfer roller **312** serves both as an extension roller and a primary transfer roller. In other words, in addition to functioning as an extension roller, the extension-cum-primary transfer roller **312** corresponds to a primary transfer roller for the photoconductor **301**. According to the second embodiment, the extension-cum-driving roller **311** serves both as an extension roller and a secondary transfer roller in association with a secondary transfer roller (secondary transfer member) **310**. A color image formed on the intermediate transfer belt **300** is transferred onto a sheet **314** of paper, which is a transfer material, by applying a predetermined voltage onto the secondary transfer roller **310**. Excess toner remaining on the intermediate transfer belt **300** is collected by a toner cleaning unit **313**.

Changes in the length of the intermediate transfer belt **300** can be compensated by rotating the extension-cum-primary transfer roller **212** along a circumference of the photoconductor **201**.

According to the second embodiment, at least one roller functions as both the primary transfer roller and the extension roller, and one roller functions as the driving roller and the secondary transfer opposite roller. Thus, at least two rollers can be omitted, thereby further reducing cost. Moreover, a shorter intermediate transfer belt can be used, thereby reducing cost and size of an image forming apparatus.

FIG. **4** is a schematic of an arrangement according to a third embodiment of the present invention. The third embodiment is different from the second embodiment in that an extension-cum-secondary transfer roller **412** serves as a secondary transfer roller (secondary transfer member) in association with the secondary transfer roller **310**, and an extension-cum-driving roller **411** serves as a primary transfer roller. The rest of the configuration is the same as that shown in FIG. **3**.

Changes in the length of the intermediate transfer belt **300** can be compensated by rotating the extension-cum-driving roller **411** along a circumference of the photoconductor **301**.

According to the third embodiment, at least one roller functions as both the primary transfer roller and the driving roller, and one roller functions as the extension roller and the secondary transfer opposite roller. Thus, at least two rollers can be omitted, thereby further reducing cost. Moreover, a shorter intermediate transfer belt can be used, thereby reducing cost and size of an image forming apparatus.

A fourth embodiment according to the present invention is described with reference to FIG. **3**. If the extension-cum-primary transfer roller **312** is made of a hard material such as metal, the intermediate transfer belt **300** slips on the extension-cum-primary transfer roller **312**, which causes a defective transfer of images, i.e., an image is not properly transferred. Accordingly, it is preferable that the extension-cum-primary transfer roller **312** is coated with an elastic layer that is sufficiently hard. Otherwise, the intermediate transfer belt **300** cannot be rotated stably, which causes color misalignments.

Assume that the photoconductors **301** to **304** each have a diameter of 24 millimeters (mm), distance between any two adjacent photoconductors is 53.4 mm, and the extension-cum-driving roller **311** and the extension-cum-primary transfer roller **312** respectively have diameters of 17 mm. Then, the

extension-cum-driving roller **311** and the extension-cum-primary transfer roller **312** have a metal core with a diameter of 16 mm coated with an elastic layer of 0.5 mm, so that the outer diameters of the rollers become 17 mm. Table 1 depicts experiment results of defective transfer and color misalignments at different hardness levels of rubber of the elastic layer. When the ASKER C hardness of the elastic layer exceeds 50 degrees, a defective transfer occurs, and when the ASKER C hardness is below 30 degrees, color misalignment occurs. In other words, neither defective transfer nor color misalignment occur when the ASKER C hardness of the elastic layer is between 30 degrees and 50 degrees. The standard of color misalignment is an average+3s=200 micrometers, where s is a standard deviation.

TABLE 1

	ASKER C hardness (degree)					
	20	30	40	50	60	70
Defective transfer	A	A	A	A	M	M
Color misalignment	M	A	A	A	A	A

M: moderate,
A: almost not observed

Therefore, it is preferable that an elastic layer having the ASKER C hardness of 30 degrees to 50 degrees is provided on the extension-cum-primary transfer roller **312** so that defective transfer and color misalignment can be prevented from occurring and the image quality is improved. The elastic layer can be made of ethylene-propylene diene monomer (EPDM), nitrile butadiene rubber (NBR), etc.

The same effects can be achieved by applying the technique of the fourth embodiment to the third embodiment shown in FIG. **4**. In other words, an elastic layer having the ASKER C hardness of 30 degrees to 50 degrees can be provided on the extension-cum-driving roller **411**.

A fifth embodiment according to the present invention is described with reference to FIG. **5**. In the fourth embodiment an elastic layer having the ASKER C hardness of 30 degrees to 50 degrees is provided on the extension-cum-primary transfer roller **312** (or the extension-cum-driving roller **411**) thereby almost preventing occurrence of color misalignment. In the fifth embodiment, an extension-cum-primary transfer roller **511** is arranged at a position shifted, for example, by 7 mm from a photoconductor **301** to a downstream side in a direction of movement of the intermediate transfer belt **300**, and the photoconductor **301** is shifted, for example, by 0.5 mm toward the intermediate transfer belt **300** so that the photoconductor **301** pushes down the intermediate transfer belt **300**. Moreover, an extension roller **509** is provided. Accordingly, a transfer nip is formed between the intermediate transfer belt **300** and the photoconductor **301**, i.e., the extension-cum-primary transfer roller **511** does not apply pressure directly or via the intermediate transfer belt **300** on the photoconductor **301**. Therefore, it is possible to set the hardness of the extension-cum-primary transfer roller **511** without considering a defective transfer.

Amounts of the shifts can be arbitrarily set so that the interval between the photoconductor **301** and the extension-cum-primary transfer roller **511** exceeds the thickness of the intermediate transfer belt **300**.

A sixth embodiment according to the present invention is described with reference to FIG. **5**. The same experiment as that of the fourth embodiment was conducted, and Table 2 depicts experiment results. A target standard of color misalignment for a high quality image is an average+3s=120 micrometers. Results show that the hardness of the extension-cum-primary transfer roller **511** does not affect the image transfer, and particularly high quality images can be obtained by setting the hardness at 50 degrees or more.

TABLE 2

	ASKER C hardness					
	20	30	40	50	60	70
Defective transfer	A	A	A	A	A	A
Color misalignment	M	A	A	A	N	N

M: moderate,
A: almost not observed,
N: not observed

Assume that the photoconductors **301** to **304** each have a diameter of 24 mm, distance between any two adjacent photoconductors is 53.4 mm, and the extension-cum-primary transfer roller **511** and the extension-cum-secondary transfer roller **412** respectively have diameters of 17 mm. Then, the extension-cum-primary transfer roller **511** and the extension-cum-secondary transfer roller **412** have a metal core with a diameter of 16 mm coated with an elastic layer of 0.5 mm, so that the outer diameters of the rollers become 17 mm.

According to the sixth embodiment, an elastic layer having the ASKER C hardness of 50 degrees or more is provided on the extension-cum-primary transfer roller **511**. As a result, defective transfer and color misalignment can be prevented from occurring so that image quality can be improved. The elastic layer can be made of EPDM, NBR, etc.

Even when a metal roller was used as the extension-cum-primary transfer roller **511**, high quality images were obtained without much color misalignment.

A seventh embodiment according to the present invention is described with reference to FIG. **6**. In the seventh embodiment, primary transfer rollers **505** to **507** corresponding to the photoconductors **302** to **304** and the photoconductors **302** to **304** are also shifted in the same manner and as the extension-cum-primary transfer roller **511** and the photoconductor **301** by substantially the same amount as those of the extension-cum-primary transfer roller **511** and the photoconductor **301** described in the fifth embodiment shown in FIG. **5**. Furthermore, a power source **601** applies the same amount of voltage to the primary transfer rollers **505** to **507** and the extension-cum-primary transfer roller **511**. The rest of the structure is the same as that shown in FIG. **5**.

Because all primary transfer rollers and all photoconductors are shifted by substantially the same amount, the amount of voltage drop onto the intermediate transfer belt **300** is the same at each primary transfer position. As a result, the same transfer electric field is formed and substantially a transfer nip having substantially the same width is formed at each primary transfer position, so that images can be transferred properly.

As a result, at least two rollers can be omitted and a shorter intermediate transfer belt can be used thereby reducing cost. Furthermore, a transformer of the power source can be integrated, thereby further reducing cost.

The amounts of shift are substantially the same at all primary transfer positions in the seventh embodiment. However, when a toner is employed that easily changes in charge amount when transferred, each of the primary transfer rollers can be shifted by an appropriate amount, so as to control the amount of voltage drop and set an optimum transfer electric field for each color. Furthermore, each of the photoconduc-

tors can be shifted by an appropriate amount to control the transfer nip, so that images can be transferred properly.

FIG. **7** is a schematic of an arrangement according to an eighth embodiment of the present invention. In the eighth embodiment, an extension-cum-primary transfer roller **712** is arranged at a position shifted by 7 mm from the photoconductor **301** toward a downstream side in a direction of movement of the intermediate transfer belt **300**, and the photoconductor **301** is shifted by 0.5 mm toward the intermediate transfer belt **300** so as to push the intermediate transfer belt **300**. Furthermore, the extension-cum-primary transfer roller **711** is arranged at a position shifted by 7 mm from the photoconductor **304** to an upstream side in the direction of movement of the intermediate transfer belt **300**, and the photoconductor **304** is shifted by 0.5 mm toward the intermediate transfer belt **300** so as to push the intermediate transfer belt **300**. A toner cleaning unit **713** is arranged opposite to the extension-cum-primary transfer roller **711**. The toner cleaning unit **713** is, for example, a brush.

Accordingly, the arrangement only includes a total of four rollers, i.e., two extension rollers and also serving as primary transfer rollers, and two rollers used exclusively as primary transfer rollers. Compared to the conventional technology employing eight rollers, costs can be largely reduced, and an image forming apparatus can be made compact.

Furthermore, by relatively shifting the photoconductors **302**, **303** or the primary transfer rollers **505**, **506** in the same manner and by substantially the same amount as those of the photoconductor **301** and the extension-cum-primary transfer roller **712**, the same voltage is applied at each primary transfer position. By setting the voltage of the toner cleaning unit **713** and the secondary transfer roller **310** based on the primary transfer voltage, costs of the power source can be reduced.

The extension-cum-primary transfer roller **712** can be arranged at a position directly opposite to the photoconductor **301**, so that the length of the intermediate transfer belt **300** can be further reduced.

According to an aspect of the present invention, tandem-type color image forming apparatuses can be made compact, and can produce high quality images free of color registration at high speed and at lower cost.

Although the invention has been described with respect to a specific embodiment for a complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art that fairly fall within the basic teaching herein set forth.

What is claimed is:

1. An image forming apparatus comprising:

a belt that rotates around a plurality of rollers;

a plurality of image carriers configured to carry toner images, the image carriers arranged in contact with a first side of the belt at a plurality of primary transfer positions;

a plurality of primary transfer members arranged in contact with a second side of the belt opposite to the first side, wherein each primary transfer member applies a voltage to a corresponding one of the primary transfer positions so that toner images on each image carrier are sequentially transferred onto the belt to be superposed on one another and then transferred at once onto a transfer material at a secondary transfer position, wherein

at least one of the primary transfer members serves as an extension roller, the extension roller configured to compensate for changes in the length of the belt by rotating along a circumference of one of the plurality of image carriers.

2. The image forming apparatus according to claim **1**, further comprising a secondary transfer member configured to apply a voltage to the secondary transfer position, wherein

at least one of the rollers serves as an electrode opposite to the secondary transfer member.

3. The image forming apparatus according to claim **2**, wherein one of the primary transfer members serves as the secondary transfer member.

4. The image forming apparatus according to claim **1**, wherein at least one of the rollers serves as one of the primary transfer members and a driving unit that drives the belt.

5. The image forming apparatus according to claim **1**, wherein the roller serving as the primary transfer member is electrically conductive, and is coated with an elastic layer of an asker C hardness of 30 degrees to 50 degrees.

6. The image forming apparatus according to claim **5**, wherein a voltage of a same magnitude is applied to the roller serving as the primary transfer member and at least one of the primary transfer members other than the roller serving as the primary transfer member.

7. The image forming apparatus according to claim **1**, wherein a point of contact of the roller serving as the primary transfer member and the belt is shifted from a point of contact of the image carrier and the belt of a corresponding primary transfer position.

8. The image forming apparatus according to claim **7**, wherein the roller serving as the primary transfer member is electrically conductive, and is coated with an elastic layer of an asker C hardness of 50 degrees or more.

9. The image forming apparatus according to claim **7**, wherein

a point of contact of the roller serving as the primary transfer member located far upstream in a direction of movement of the belt and the belt is shifted upstream from a point of contact of the image carrier and the belt of a corresponding primary transfer position, and

a point of contact of the roller serving the primary transfer member located far downstream in the direction of movement of the belt and the belt is shifted downstream from a point of contact of the image carrier and the belt at a corresponding primary transfer position.

10. An image forming apparatus comprising:

a belt that rotates around a plurality of rollers;

a plurality of image carriers configured to carry toner images, the image carriers arranged in contact with a first side of the belt at a plurality of primary transfer positions;

a plurality of primary transfer members arranged in contact with a second side of the belt opposite to the first side, wherein each primary transfer member applies a voltage to a corresponding one of the primary transfer positions so that toner images on each image carrier are sequentially transferred onto the belt to be superposed on one another and then transferred at once onto a transfer material at a secondary transfer position, wherein

at least one of the primary transfer members serves as an extension-cum-driving roller, the extension-cum-driving roller configured to drive the belt and compensate for changes in the length of the belt by rotating along a circumference of one of the plurality of image carriers.

11. The image forming apparatus according to claim **10**, further comprising a secondary transfer member configured to apply a voltage to the secondary transfer position, wherein

at least one of the rollers serves as an electrode opposite to the secondary transfer member.

12. The image forming apparatus according to claim 10, wherein the rollers serving as the primary transfer members are electrically conductive, and is coated with an elastic layer of an asker C hardness of 30 degrees to 50 degrees.

13. The image forming apparatus according to claim 10, wherein points of contact of the rollers serving as the primary transfer members and the belt are shifted from points of contact of the image carrier and the belt of a corresponding primary transfer position.

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